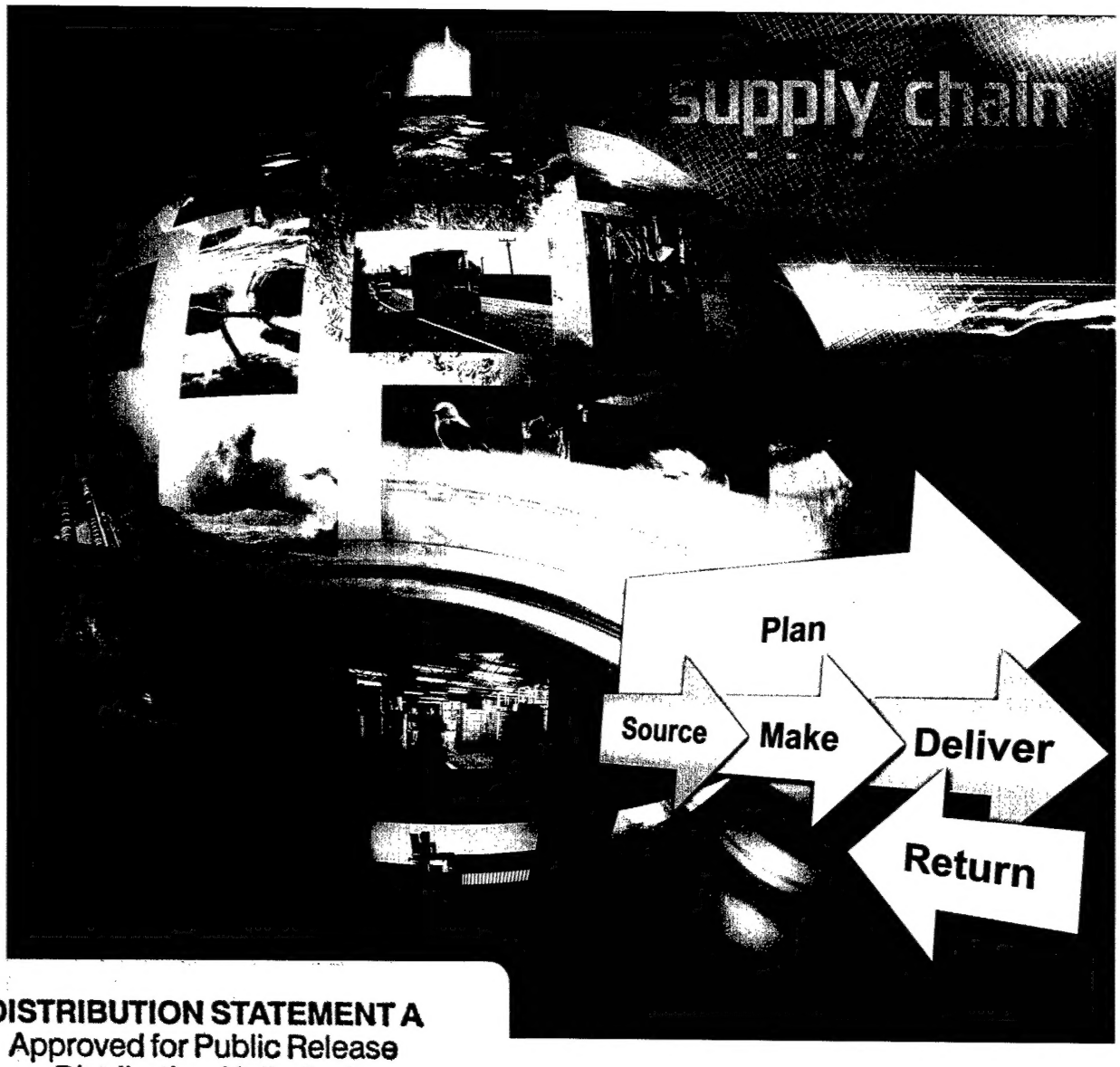
*Logistics Management Institute*

# GreenSCOR
## Developing a Green Supply Chain Analytical Tool

LG101T4




**DISTRIBUTION STATEMENT A**
Approved for Public Release
Distribution Unlimited

LMI

*Logistics Management Institute*

# GreenSCOR
## Developing a Green Supply Chain Analytical Tool

LG101T4

March 2003

Raheem Cash
Taylor Wilkerson





Logistics Management Institute
2000 Corporate Ridge
McLean, VA 22102-7805

# REPORT DOCUMENTATION PAGE

*Form Approved*
*OMB No. 0704-0188*



**1. REPORT DATE** *(MM-YYYY)*
03-2003

**2. REPORT TYPE**
Final

**3. DATES COVERED** *(From - To)*

**4. TITLE AND SUBTITLE**
GreenSCOR

Developing a Green Supply Chain Analytical Tool

**5a. CONTRACT NUMBER**
GS-23F-9737H

**5b. GRANT NUMBER**

**5c. PROGRAM ELEMENT NUMBER**

**6. AUTHOR(S)**
Cash, Raheem ; Author
Wilkerson, Taylor ; Author

**5d. PROJECT NUMBER**

**5e. TASK NUMBER**
LG101.50.05

**5f. WORK UNIT NUMBER**

**7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)**
Logistics Management Institute
2000 Corporate Ridge
McLean, VA 22102-7805

**8. PERFORMING ORGANIZATION REPORT NUMBER**
LMI-LG101T4

**9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)**
UDUSD (L&MR) Supply Chain Integration
3500 Defense Pentagon
Rm 3E808
Washington, DC 20301-3500

**10. SPONSOR/MONITOR'S ACRONYM(S)**

**11. SPONSOR/MONITOR'S REPORT NUMBER(S)**

**12. DISTRIBUTION / AVAILABILITY STATEMENT**
A Approved for public release; distribution is unlimited.

**13. SUPPLEMENTARY NOTES**

**14. ABSTRACT**
An emerging area in supply chain practice is green supply chain management, which integrates environmental management with traditional supply chain management. GreenSCOR is the solution to closing this gap. GreenSCOR is a modification of version 5.0 of the Supply Chain Operations Reference (SCOR) model developed by the Supply-Chain Council (SCC). LMI used SCOR as a foundation because it has been proven over several years of continual development. SCOR also fit well with the LCA approach now common in environmental management.

**15. SUBJECT TERMS**
supply chain; SCOR; green supply chain; environment; analytical tool

| **16. SECURITY CLASSIFICATION OF:** | | | **17. LIMITATION OF ABSTRACT** | **18. NUMBER OF PAGES** | **19a. NAME OF RESPONSIBLE PERSON** |
|---|---|---|---|---|---|
| **a. REPORT** | **b. ABSTRACT** | **c. THIS PAGE** | Unclassified Unlimited | 36 | Nancy E. Handy |
| UNCLASSIFIED | UNCLASSIFIED | UNCLASSIFIED | | | **19b. TELEPHONE NUMBER** *(include area code)* 703-917-7249 |

# Executive Summary

Supply chain management is a continually evolving field, relying on breaking down internal and external organizational barriers to gain efficiencies and improve end-to-end customer support. An emerging area in supply chain practice is green supply chain management, which integrates environmental management with traditional supply chain management.

Green supply chain management has developed from two perspectives. Environmental managers have started using a life-cycle analysis (LCA) approach to managing environmental impacts. This approach looks at a product's environmental impacts, from raw material extraction through manufacturing and use to final disposal. Naturally, this approach includes many supply chain processes, such as material handling, transportation, packaging, and manufacturing.

Likewise, supply chain managers have found process improvements by breaking down the internal barriers between supply chain and environmental managers. By planning process activities with environmental impacts in mind, managers can reduce costs and increase customer support.

While many firms are working to integrate these two approaches, the integration is far from complete. There are still significant cultural barriers between environmental and supply chain managers, and green supply chain projects often focus on discrete supply chain processes rather than the end-to-end chain. Also, there is no tool for integrating these two practice areas.

GreenSCOR is the solution to closing this gap. GreenSCOR is a modification of version 5.0 of the Supply Chain Operations Reference (SCOR) model developed by the Supply-Chain Council (SCC). The SCC is an organization of more than 700 members with a focus on improving supply chain performance. With that goal in mind, SCC developed the SCOR model as an analytical tool for analyzing, comparing, and improving an organization's supply chain.

LMI used SCOR as a foundation because it has been proven over several years of continual development. SCOR also fit well with the LCA approach now common in environmental management. Because SCOR is a proven supply chain tool, we

made every effort not to take any elements out of the tool in our development. Rather, we strove to add environmental considerations throughout the tool.

The resulting GreenSCOR model is an integrated green supply chain management tool that will allow users to seamlessly manage their supply chain and environmental impacts, resulting in more efficient operations and lower costs.

The next steps for GreenSCOR include its use in a pilot study, education of the supply chain and environmental communities, and inclusion in the next release of the SCOR model. By integrating environmental and supply chain management, GreenSCOR provides a foundation for improving operational activities while reducing environmental impacts. The end result is a more efficient and less expensive operations environment.

# Contents

# FIGURES



# TABLES

# Chapter 1
# Introduction

The field of supply chain management has evolved over the years. What started as internal process improvements gained by breaking down organizational barriers has outgrown corporate boundaries to include collaboration between trading partners. As supply chain management progressed, managers realized there were great efficiency gains made when organizational units collaborate.

To help managers obtain these efficiencies, the Supply-Chain Council (SCC), a not-for-profit industry group, developed the Supply Chain Operations Reference (SCOR) model. SCOR breaks the supply chain down into discrete process elements, each with associated metrics and best practices. Managers can use these elements to evaluate and compare their operations and pinpoint areas for process improvements.

Likewise, environmental management has matured significantly from its beginnings in the late 1960s and early 1970s. What began as an arguably desperate effort to trap, treat, and dilute air, water, and waste pollution from individual sources, evolved in the 1990s into a systematic attempt to prevent pollution at the source and manage entire ecosystems instead of specific media.

The pollution-prevention ethic represented a radical shift in the focus of environmental management. The idea was to look "upstream" at the people and functions that produce pollution. Such concepts as design for environment, industrial ecology, and product life-cycle analysis are derived from pollution prevention. Often, pollution prevention programs discover that the primary source of environmental impacts are supply chain processes (e.g., transportation, manufacturing, packaging, and material handling).

The recent inclination to look upstream has lead to an important realization among environmental managers (i.e., they cannot be successful without the cooperation of non-environmental managers). Thus far success has been limited, even when applying holistic approaches, such as environmental management systems (EMS) and life-cycle analysis (LCA).

LMI's goal was to take a closer look at two solutions designed to promote holistic approaches to environmental and supply chain management: green supply chain management and the SCOR model. We found the most effective way to ensure environmental analyses involve the entire supply chain, and simultaneously ensure supply chain analysis considers all environmental aspects, is to merge these two concepts. The result is GreenSCOR, a modification of the original SCOR model.

This report outlines the concepts behind GreenSCOR and describes our approach toward developing the model. We also present the benefits of using GreenSCOR to perform supply chain analysis, and the plans for continued evolution of the GreenSCOR model.

In Chapter 2, we define supply chain management, and detail the improvements of green supply chain management. Chapter 3 introduces the GreenSCOR model, while Chapter 4 explains the possible application of the model. As a conclusion, Chapter 5 explains the future development actions for GreenSCOR.

# ACKNOWLEDGMENTS

We would like to thank Maureen Sullivan and John Coho of the Office of the Deputy Under Secretary of Defense (Installations and Environment) for their help in developing the GreenSCOR model.

# Chapter 2
# Supply Chain and Green Supply Chain Management

The GreenSCOR model enables organizations to more effectively integrate environmental management with supply chain management. As a tool, the model is specifically designed for organizations that have already implemented the more progressive aspects of both management areas. For environmental management, this includes green supply chain management, life-cycle analysis, and green procurement. For supply chain management, this includes supply chain integration and the use of the SCOR model. This chapter provides some background on these concepts and practices.

## SUPPLY CHAIN MANAGEMENT

Supply chain management (SCM) means different things to different people. Some view SCM as incrementally improving operational efficiencies, while others see it as total integration of all organizations responsible for transforming raw materials into a finished product and delivering that product to the customer. Following are two common SCM definitions:

> The management of upstream and downstream relationships with suppliers and customers to deliver superior customer value at less cost to the supply chain as a whole.[1]

> A network of connected and interdependent organizations mutually and cooperatively working together to control, manage, and improve the flow of materials and information from suppliers to end customers.[2]

As these definitions indicate, supply chain management involves collaboration beyond organizational boundaries to optimize logistics processes through data sharing and strategic partnerships. This represents an emerging and fast-growing best practice for any organization involved in moving materials.

Supply chain management is a natural outgrowth of the disparate logistics functions prevalent during the 1960s and earlier, a time when companies often had procurement, manufacturing, warehouse, transportation, and marketing managers, each of whom existed in their own stovepipe and rarely talk with each other.

---

[1] Martin Christopher, *Logistics and Supply Chain Management*, 1992, Pearson Education Limited, Essex, England.

[2] J. Aitken, *Supply Chain Integration within the Context of a Supplier Association*, Cranfield University, PhD thesis, 1998.

Over time, organizations learned that removing the barriers between these functions improved operational efficiency. Today, companies can speed the delivery of products to customers while reducing costs and risks. These improvements are generally collected under the umbrella of logistics management.

Once an organization removes its internal barriers, the next step is to break down the barriers between different trading partners. Through integration of its own operations and the operations of its suppliers and customers, an organization can reduce the time it takes for suppliers to respond to changes in customer demand, speeding the end-to-end supply chain process and reducing the amount of inventory any one partner needs to carry.

# THE SCOR MODEL

The Supply Chain Operations Reference model is a process model developed by the Supply-Chain Council in an effort to develop a standard tool for evaluating, measuring, and improving supply chain performance. The model is currently in its fifth version.

The SCC is an industry consortium of more than 700 member organizations throughout the world. Members participate in the continual growth of the model by adding their best practices and commonly used metrics. This community development strengthens the SCOR model's role as a robust and versatile supply chain analysis tool.

*SCOR breaks the supply chain down into processes within the six categories shown in Table 2-1.*

*Table 2-1. SCOR Process Categories*

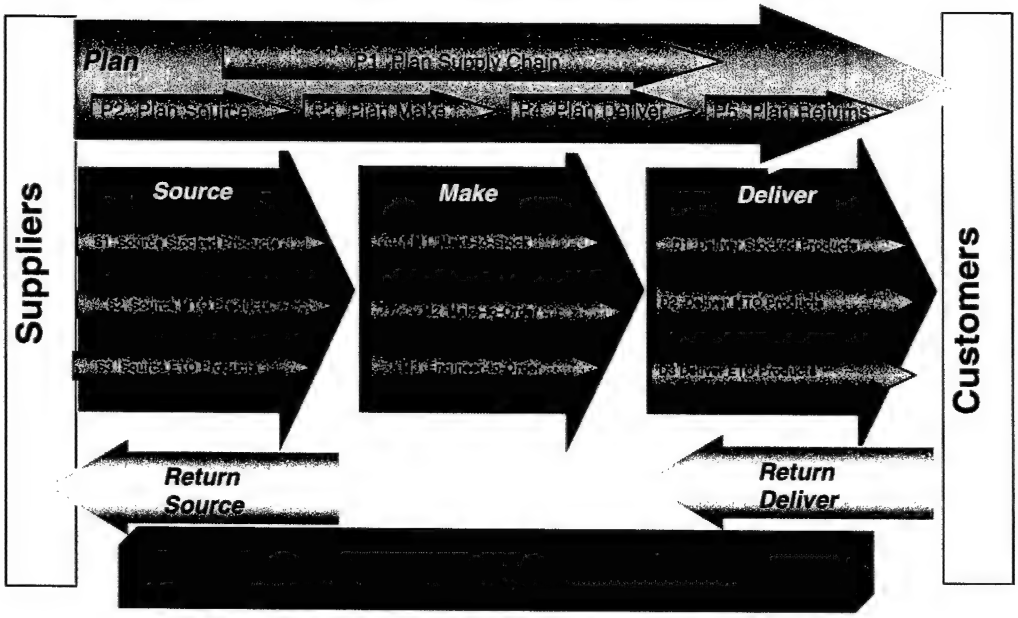
| Category | Description |
|---|---|
| Plan | Processes associated with planning, scheduling, and coordinating supply chain activities. |
| Source | Processes associated with procuring material, physically receiving material, and storing raw materials. |
| Make | Processes associated with transforming raw material into a finished product. In defense maintenance, repair, and overhaul operations, the Make category is used to model maintenance activities. |
| Deliver | Processes associated with storing, packaging, and delivering finished products to the customer. |
| Return | Processes associated with delivering and receiving material from a customer to a supplier, commonly called reverse logistics. |
| Enable | Processes that facilitate the movement of materials (e.g., business rules, data management, performance management, contract management, asset management, and compliance management). |

These processes are further broken down to form three process levels. Level 1 defines the scope of the supply chain and is used to evaluate competitive performance of the entire chain. Level 2 configures the supply chain into three primary types:

- Make to stock
- Make to order
- Engineer to order.

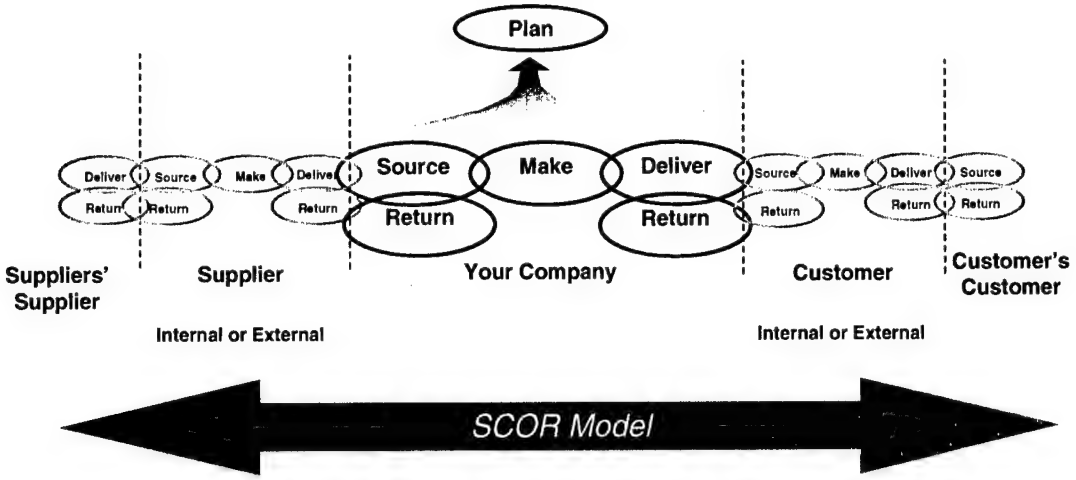
Level 3 defines the processes that compose a supply chain's operations. These levels define a company's ability to perform via the application of best practices and the use of performance metrics. Levels 1 and 2 are shown in Figure 2-1. Further process decomposition can be performed if it is useful for the specific analysis; however, this is beyond the scope of the SCOR model.

*Figure 2-1. SCOR Processes*




SCOR processes can be replicated to model supplier and customer interactions across the supply chain. In this way, a user can use the same six high-level processes to model an entire supply chain's operations, as shown in Figure 2-2.

*Figure 2-2. SCOR Depiction of End-to-End Supply Chain*




Within each SCOR process, the model includes a process element table that defines the process, provides metrics for measuring the process, and lists best practices for managing the process, complete with software features of that practice. As an analytical tool, these tables are the true power behind the model. They allow organizations to compare and link their operations using a common language and measurement base. A sample table is shown in Figure 2-3.

*Figure 2-3. Sample SCOR Process Element Table*

| Process Category: Plan Source | Process Number: P2 |
|---|---|
| **Process Category Definition** | |
| The development and establishment of courses of action over specified time periods that represent a projected appropriation of material resources to meet supply chain requirements. | |
| **Performance Attributes** | **Metric** |
| Reliability | Supplier Delivery on-time Delivery Performance<br>Supplier Fill Rate |
| Responsiveness | Cumulative Source Cycle Time |
| Flexibility | Source Flexibility |
| Cost | None identified |
| Assets | None identified |
| **Best Practices** | **Features** |
| EDI links integrate supplier resource information (inventory, capacity availability, etc.) with own resources | Inter-company resource planning with EDI/Internet communication |
| Joint Service Agreements with suppliers define the levels of "flexibility" or resource upside available within stated lead times and agreed upon conditions | None Identified |
| Distinct and consistent linkages exist to ensure disruptions and opportunities in material resources are quickly and accurately communicated and acted upon | Bi-directional Digital Links (XML, EDI, etc) or Internet procurement networks to customer service linkage |
| All key participants in the supply chain, including strategic partners, have full visibility of the demand/supply plan | Supply Chain Event Management Systems |

SCOR allocates metrics to five performance attributes, as shown in Figure 2-4. Figure 2-4 also shows the Level 1—top level—metrics the SCOR model uses to assess overall supply chain performance along each attribute.

*Figure 2-4. SCOR Performance Attributes and Level 1 Metrics*

| Performance Attribute | Performance Attribute Definition | Level 1 Metric |
|---|---|---|
| Supply Chain Delivery Reliability | The performance of the supply chain in delivering: the correct product, to the correct place, at the correct time, in the correct condition and packaging, in the correct quantity, with the correct documentation, to the correct customer. | Delivery Performance |
| | | Fill Rates |
| | | Perfect Order Fulfillment |
| Supply Chain Responsiveness | The velocity at which a supply chain provides products to the customer. | Order Fulfillment Lead Times |
| Supply Chain Flexibility | The agility of a supply chain in responding to marketplace changes to gain or maintain competitive advantage. | Supply Chain Response Time |
| | | Production Flexibility |
| Supply Chain Costs | The costs associated with operating the supply chain. | Cost of Goods Sold |
| | | Total Supply Chain Management Costs |
| | | Value-Added Productivity |
| | | Warranty / Returns Processing Costs |
| Supply Chain Asset Management Efficiency | The effectiveness of an organization in managing assets to support demand satisfaction. This includes the management of all assets: fixed and working capital. | Cash-to-Cash Cycle Time |
| | | Inventory Days of Supply |
| | | Asset Turns |

SCOR users have found the model's approach of breaking supply chains into common, discrete process activities to be a very effective method for improving performance. The common language of SCOR makes it easy for an organization to compare its performance against others within the same industry. Likewise, the common processes allow for faster application of supply chain management best practices.

# ENVIRONMENTAL MANAGEMENT

Environmental management consists of an organization's efforts to operate in accordance with environmental laws and reduce its overall impact on the environment. For some organizations, the regulatory compliance is emphasized, and avoiding the fines and penalties associated with regulations (such as the Clean Water Act and Clean Air Act) is the primary function of the environmental management professionals.

Organizations interested in their environmental impacts in addition to regulatory compliance will instruct their environmental professionals to identify ways of reducing emissions and wastes, regardless of whether or not a regulation requires such action.

Apart from the motivation to comply with regulations, environmental managers tend to employ two management strategies: end-of -pipe and systems strategies.

The end-of-pipe strategy focuses on specific pollutants that emanate from specific processes and affect a specific environmental resource. In the past, this strategy was particularly attractive because most of the environmental regulations were structured in the same manner. The end-of-pipe strategy has generally gone out of fashion. Regulators and the regulated alike began to realize the inefficiencies of creating a mess only to clean it up. More efficient approaches to environmental management were necessary. This led to the second management strategy, which can be broadly described as a systems strategy.

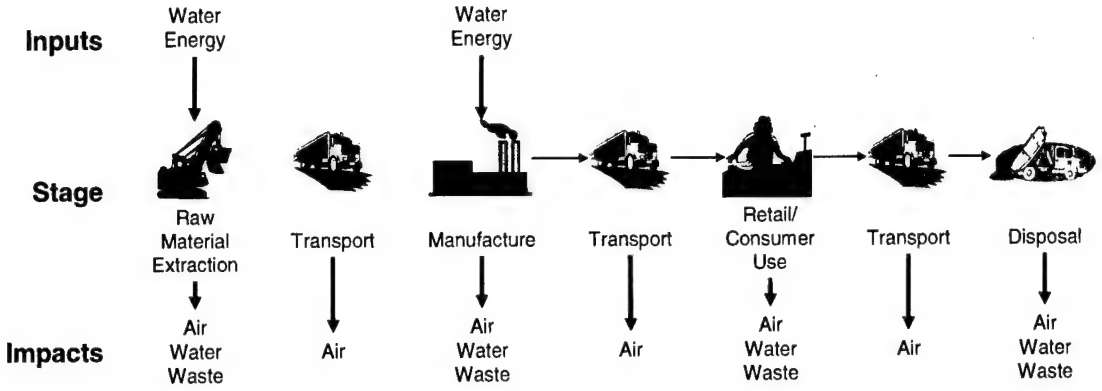
Regulators began to focus on environmental impacts to ecosystems while regulated firms began to explore ways to reduce or eliminate pollution "upstream" in their production processes. This pollution prevention approach led quite naturally to a life-cycle analysis approach—discussed in more detail below—and environmental management systems. Each involves a close holistic look at an organization's operations and their associated effects on the environment.

The environmental community as a whole recognizes that the systems approach to environmental management results in more than just less pollution. Cost reductions and improved efficiency are quite common. These successes and benefits have sparked a proliferation of management concepts underneath the systems umbrella. Of particular interest is the green supply chain management concept. Before delving into green supply chain, however, it is important to take a closer look at the closely related LCA management approach.

## LIFE-CYCLE ANALYSIS

Environmental life-cycle assessments evaluate the environmental impacts that result from an organization's processes associated with a specific product or service. The scope goes beyond the manufacturing stage and looks both upstream and downstream from a process. Thus environmental impacts are identified—from the moment of raw material extraction to final disposal (i.e., the entire life cycle of the product or service). Figure 2-5 provides an illustration of the life-cycle scope.

*Figure 2-5. Product Environmental Life-Cycle*




The LCA practitioner defines the exact scope of a specific life-cycle assessment; thus, the diagram in Figure 2-5 may be truncated for some assessments. Regardless of the selected scope, LCA generally entails three interrelated components:

1. Identification and quantification of energy and resource use and environmental releases to air, water, and land
2. Qualitative and quantitative characterization and assessment of the consequences on the environment (impact analysis)
3. The evaluation and implementation of opportunities to reduce environmental impacts.

# THE GREEN SUPPLY CHAIN CONCEPT

The findings from LCAs led many firms to examine the logistical aspects of the development of their product or service. There was increased scrutiny of what items are purchased for use in various processes, the effects of manufacturing processes, and how products are packaged and delivered. The effort to reduce the impact of these activities on the environment is referred to as green supply chain management.

Firms have generally taken two approaches to greening their supply chains. The first looks externally to its various suppliers. Suppliers are asked to provide evidence of their operations meeting relevant environmental requirements and, in some cases (Toyota and Ford for example), evidence of ISO14001 certification.

The second approach is an internal examination of how a firm designs, produces, and ships its products. Packaging reduction and the reduction of toxic materials usage have been the key focus areas.

Firms conducting green supply chain analyses have seen many benefits, both environmentally and financially. Pepsi-Cola, for example, saved $44 million by

switching from corrugated to reusable plastic shipping containers for one liter and 20-ounce bottles, conserving 196 million pounds of corrugated material. Similarly, Dow Corning saved $2.3 million by using reconditioned steel drums in 1995, conserving 7.8 million pounds of steel.

# GAPS IN GREEN SUPPLY CHAIN MANAGEMENT

Oddly, most firms implementing green supply chain practices have not actually integrated environmental considerations into their supply chain management processes. The distinction is critical: It is one thing to look at pieces of a supply chain and green them; it is quite another to examine the decisions and actions that drive the entire supply chain (e.g., its management).

## Isolated Analysis

Traditional green supply chain analysis occurs apart from standard supply chain analysis. The approach is generally driven by a need to "green" an existing industrial process or other aspect of the chain. The results can be quite positive from an environmental perspective; however, when those responsible for reviewing a firm's overall supply chain performance make changes, the environmental aspects often are not considered. It is only after these changes have been implemented and their effects revealed that the idea of "greening" has the opportunity to emerge.

The disjointed nature of this process is not merely an intellectual concern. Failure to integrate supply chain optimization efforts with green supply chain efforts results in a failure to realize potential financial and functional benefits and, in some cases, negates the benefits derived from any one area.

Logisticians may successfully increase revenue via a supply chain innovation while simultaneously increasing costs because their innovation increases energy use or creates a need for increased emissions management. In opposition, successful greening of a supply chain might lower regulatory costs but seriously reduce the organization's ability to satisfy customers. For the sake of the organization, synergy must be found between the two analyses.

## Isolated Analysts

As has been recognized in other environmental initiatives (such as pollution prevention and green procurement, a subset of green supply chain management that looks solely at purchasing issues), anyone directly responsible for the processes that impact the environment must be fully aware of the processes' effects and the options for reducing them.

The major Environmental Protection Agency effort to develop green specifications is an excellent example of this principle. It was realized that the increasing availability of green products and services do not automatically increase the use

of such products; the purchasers have to be greened as well. The same holds true for greening the supply chain.

Unfortunately, most green supply chain efforts are initiated from outside the supply chain divisions, usually by the environmental, health, and safety division. Greening efforts will not be truly successful until the supply chain mangers themselves can identify the environmental effects of their decisions and initiate the coordination with the environmental professionals in their firms to reduce or avoid these impacts.

Integrating environmental concepts into supply chain management requires substantial education of supply chain practitioners. Such education would be futile, however, unless the lessons learned were fully integrated into routine supply chain decision-making.

## Closing the Gaps

None of the gaps in green supply chain management are insurmountable. Practices (such as supply chain management and previously mentioned greening efforts) have demonstrated that stovepipes can be broken down, and collaborative process design and improvement can be accomplished. Organizations need only make a strategic effort to communicate, educate, and motivate their employees to make the cultural changes required, and provide tools to enable the changes.

Unfortunately, based on our research there is currently no analytical tool that integrates environmental and supply chain considerations. It is often easier to get people to work together if they both have a common framework to work within—a framework that gives all concerned a common language and perspective to bring them together.

# Chapter 3
# GreenSCOR Model

To address the gaps in green supply chain management, LMI set out to develop a tool for implementing green supply chain management. This became the GreenSCOR model.

## THE GREENSCOR CONCEPT

The concept behind GreenSCOR is fairly simple. Because the SCOR model already is a robust supply chain management tool, we built upon its foundation to include environmental elements. The goal was to create an analytical tool that provides a clear view of the connection between supply chain functions and environmental issues; thereby, improving organizational management of both.

## APPROACH

We used the SCOR model as the basis for developing a green supply chain model. The SCOR model is a robust supply chain tool that has undergone several iterations to incorporate input from Supply-Chain Council members. Using a tool that is proven and recognized speeds the acceptance of GreenSCOR as a green supply chain management tool.

The guiding principle for this project was to maintain the integrity of the current SCOR model (version 5.0) and to fully integrate the environmental concepts. The desire was to avoid creating a separate, standalone tool that could be easily ignored. In pursuing the greening process we made every effort to leave existing definitions and formatting unchanged.

GreenSCOR development occurred in four basic steps:

1. Conduct background research on green supply chain best practices and metrics.

2. Evaluate the existing SCOR model processes for environmental impacts.

3. Modify the SCOR model to include environmental metrics and best practices.

4. Capture the changes in a report that specifies why each change is made and the impact on supply chain operations.

## SCOR Process Review

We reviewed the processes in the SCOR model and assessed the impact each process had on the environment. Table 3-1 shows the environmental impacts of the SCOR Level 1 processes, the highest level of analysis. This process included a detailed review of the process definition against our knowledge of where environmental impacts are created in the physical transformation and flow of products.

*Table 3-1. SCOR Process Environmental Impacts*

| SCOR process | Potential impact |
|---|---|
| Plan | • Plan to minimize energy consumption and hazardous material usage<br>• Plan the handling and storage of hazardous materials<br>• Plan for the disposal of ordinary and hazardous waste<br>• Plan compliance of all supply chain activities |
| Source | • Select suppliers with positive environmental records<br>• Select materials with environmentally friendly content<br>• Specify packaging requirements<br>• Specify delivery requirements to minimize transportation and handling requirements |
| Make | • Schedule production to minimize energy consumption<br>• Manage waste generated during the Make process<br>• Manage emissions (air and water) from the Make process |
| Deliver | • Minimize use of packaging materials<br>• Schedule shipments to minimize fuel consumption |
| Return | • Schedule transportation and aggregate shipments to minimize fuel consumption; prepare returns to prevent spills of hazardous materials (oils, fuels, etc.) from damaged products |

For each of these Level 1 processes, we looked for gaps in the process elements. One significant discovery was the lack of any process element for waste accumulation and disposal for waste generated during the Make process—an excellent example of the stovepipe nature of environmental management of most organizations.

The manufacturing process invariably results in a waste stream of some kind that simply cannot be ignored. Organizations do not ignore this waste; their environmental staff manages the problem of waste. But waste is not a paramount concern for those managing the *entire* supply chain. To remedy this situation, GreenSCOR includes a new process element for each of the Make functions to address waste disposal and management.

There also is a missing element in the Return process. Return, as currently conceived in SCOR, is the return of defective or excess products for repair or

exchange. From an environmental perspective however, there may be other reasons for product returns.

Increasingly, products are returned for recycling, reuse, or remanufacture. Also, in some instances firms are responsible for the disposal of all its products, even after consumer use. Thus the current return processes needed modification to capture the return for recycling, reuse, or remanufacture.

With the top-level processes and process elements revisions complete, we moved to assess the environmental integration opportunities for the SCOR best practices and metrics associated with each element.

## Best Practices and Metrics Review

SCOR metrics are aligned with five specific supply chain performance attributes defined by the model. Because SCOR was developed as a supply chain model, these attributes do not directly address environmental concerns. To effectively develop environmentally oriented metrics, we needed to link the performance attributes to environmental impacts.

We investigated several options for managing the placement of environmental metrics, including creating a sixth attribute, Environmental Impact, which would have its own definition. We wanted to avoid changing any of the fundamentals of SCOR, however, and needed to avoid creating an attribute that would be too easy to dismiss when performing analysis, thus negating the purpose of our efforts.

As a compromise, we established parallel environmental definitions to use as a framework for developing environmental metrics. Table 3-2 shows the SCOR performance attribute definitions with their corresponding environmental definitions.

The environmental definitions serve only as a guide to assist our development of metrics. They ensure the metrics for each process element are consistent; they are not recommended for addition to the SCOR model itself.

*Table 3-2. SCOR Performance Attribute Environmental Linkage*

| Performance attribute | SCOR definition | Environmental definition |
|---|---|---|
| Reliability | The performance of the supply chain in delivering: the correct product, to the correct place, at the correct time, in the correct condition and packaging, in the correct quantity, with the correct documentation, to the correct customer. | The ability to deliver the correct product reduces waste from product discards; reduces air emissions and fuel use from extra transportation for returned products. Proper documentation enables all players of the supply chain to keep better track of hazardous materials or toxins that are embedded in certain products; thus allowing them to arrange for proper storage, handling, and disposal. |
| Responsiveness | The velocity at which a supply chain provides products to the customer. | The environmental impacts that affect the speed of material movement, including regulatory or pollution control steps within a process. |
| Flexibility | The agility of a supply chain in responding to marketplace changes to gain or maintain competitive advantage. | The degree to which a firm can meet the environmental demands of its customers. This pertains to the products, their production, transportation and recyclability, etc. |
| Costs | The costs associated with operating the supply chain. | The costs of environmental compliance and cleanup as well as energy costs. |
| Asset management efficiency | The effectiveness of an organization in managing assets to support demand satisfaction. This includes the management of all assets: fixed and working capital. | Managing assets in a manner that reduces environmental impacts and reduces internal costs. |

Metrics were designed to address the environmental impacts associated with each process element. We avoided metrics that captured environmental improvements but did not lead to supply chain improvement along at least one of the performance attributes. This kept the focus of the model on leveraging environmental improvements to improve customer service. As with the accompanying supply chain metrics, the environmental metrics are distinct and measurable, allowing for trend analysis.

The addition of best practices was less problematic because there are no uniquely supply chain–oriented characteristics. Best practices are simply best practices, regardless of the discipline.

The best practices included for each process element (when applicable), were included based upon our knowledge of the existing and emerging practices for environmental management within private industry and the public sector. The primary challenge was to ensure the practices identified were generally applicable across industry sectors. Figure 3-1 and Figure 3-2 provide examples of the metrics and best practices (indicated in green text) included in the GreenSCOR.

*Figure 3-1. Sample GreenSCOR Process Table (Select Final Supplier)*

| Process Element: Select Final Supplier(s) and Negotiate | Process Element Number: S3.2 |
|---|---|
| **Process Element Definition** | |
| The identification of the final supplier(s) based on the evaluation of RFQs, supplier qualifications and the generation of a contract defining the costs and terms and conditions of product availability. | |
| **Performance Attributes** | **Metric** |
| Reliability | % Supplier contracts negotiated meeting target terms and conditions for quality, delivery, flexibility and cost<br>% of suppliers with an EMS or ISO 14001 certification |
| Responsiveness | Source Selection Cycle Time |
| Flexibility | % Single and/or Sole Source Selections |
| Cost | Sourcing Costs as a % of Product Acquisitions Costs |
| Assets | None Identified |
| **Best Practices** | **Features** |
| Electronic data interchange is used to send RFQs and technical information to and from potential suppliers | None Identified |
| On line RFQ processes linked into the document management process reduces cycle time and product management costs | None Identified |
| Supplier certification programs can reduce the cycle time for certifying existing suppliers to provide new technologies | None Identified |
| Utilize concurrent engineering with suppliers to allow them to provide engineering and product performance test data | None Identified |
| On line document management and automated supplier approval processes can reduce the cycle time and costs associated with managing supplier evaluations<br>On-line availability to supplier financials | None Identified |
| Select firms that are ISO 14001 certified or similar<br>Select firms that have implemented an EMS<br>Establish environmental partnerships with suppliers<br>Select firms that offer product "Take-back" programs | |

*Figure 3-2. Sample GreenSCOR Process Table (Release Finished Product)*

| Process Element: Release Finished Product to Deliver | Process Element Number: M2.6 |
|---|---|
| **Process Element Definition** | |
| Activities associated with post-production documentation, testing, or certification required prior to delivery of finished product to customer. Examples include assembly of batch records for regulatory agencies, laboratory tests for potency or purity, creating certificate of analysis, and sign-off by the quality organization. | |
| **Performance Attributes** | **Metric** |
| Reliability | % Release errors<br>% products meeting specified environmental performance requirements<br>% of products with proper environmental labeling (if required) |
| Responsiveness | Quarantine or Hold time<br>Release process cycle time |
| Flexibility | None Identified |
| Cost | Release cost per unit |
| Assets | None Identified |
| **Best Practices** | **Features** |
| Accurate and low cost batch records for regulatory compliance | Electronic batch records |
| Review batch records by exception | Electronic batch records linked to process plans/recipes and exceptions flagged |
| Automated notification of laboratory regarding sample availability | Interface between production system and LIMS |
| Implement EMS program. | |
| Implement hazardous materials "pharmacy" system | |

# GREENSCOR AND ENVIRONMENTAL LIFE-CYCLE ANALYSIS

In many respects, greening the supply chain is an extension of the life-cycle analysis concept. LCA usually focuses on the life of a product, irrespective of the specific organizations involved. In such cases (for example the paper-versus-plastic debate), the aim is to illustrate all of the environmental effects associated with bringing the product into existence and its ultimate destruction.

As mentioned previously, green supply chain analysis attempts to look at the environmental impacts posed by the specific products developed by a specific organization. Such an approach cannot be generic. Organizations in similar industries may produce vastly different products and in a number of ways.

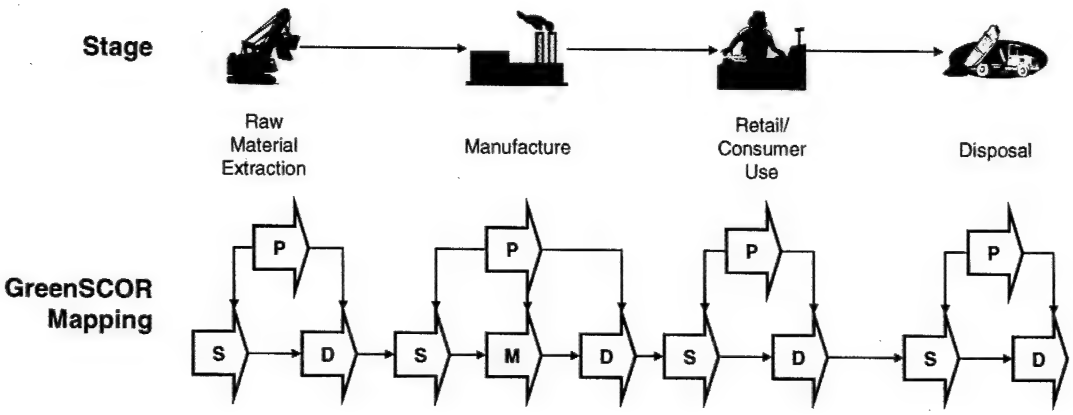
This variety is reflected in the conduct of green supply analysis. Some firms zero-in on distinct aspects of the supply chain, and green what they can. Others have turned to their suppliers, which they see as a source of many of their environmental problems, and insisted upon improved environmental stewardship. In all

cases, these efforts still represent a narrowly conceived definition of the supply chain.

Interestingly, the existence, importance, and inherent connectivity of the supply chain are recognized; yet when green supply chain analysis is conducted, individual links are treated like separate entities. It must be noted that this problem is the same within the supply chain community as well; SCOR is their solution and, ultimately, ours as well.

GreenSCOR is a tool that will help environmentalists and logisticians maintain the perspective of an overall supply chain of dynamic links. Each step in the standard LCA model consists of a series of smaller steps, each presenting a series of potential environmental impacts, as shown in Figure 3-3. From an environmental perspective, the true difference for LCA lies not in what GreenSCOR examines, but the level at which that examination is conducted.

*Figure 3-3. Environmental LCA and GreenSCOR*




Typical LCA focuses on the macro level environmental impacts of a product and of each stage, e.g. manufacturing plant air emissions. GreenSCOR will capture these macro impacts but also allow users to drill down to the business processes that create the impacts. This provides both macro- and microanalysis of environmental impacts to create a truly holistic management tool.

# Chapter 4
# Application of GreenSCOR

The GreenSCOR model has no intrinsic benefits; it must be propagated and used in order to have a positive impact. This requires potential users to see the benefits in the model and the green supply chain approach. In this chapter, we discuss the benefits GreenSCOR's use can bring to an organization, and we outline our future plans to illustrate these benefits via pilot studies.

## GREENSCOR BENEFITS

The following are primary benefits we see resulting from GreenSCOR's adoption:

- Improved environmental management performance
- Improved supply chain management performance
- Improved green supply chain initiatives

### Improved Environmental Management Performance

The ultimate objective of green supply chain analysis is to identify often hidden environmental impacts and take appropriate steps to mitigate them. By using SCOR as an analysis tool, an organization can take a more complete view of the supply chain itself. This ability in turn allows possible identification of more environmental aspects and impacts. The GreenSCOR elements integrated into SCOR will highlight best practices that can mitigate those impacts. Environmental performance can ultimately improve because more aspects and solutions have been identified.

Environmental management improves due to the existence of a clear set of metrics. Thus a more efficacious use of funds can be achieved and the justification required to receive funding is easier to produce. Environmental management also benefits by being able to demonstrate exactly how and where their recommended changes will impact the supply chain as a whole and which attributes will be improved.

Some specific environmental objectives could also benefit from GreenSCOR. We believe this to be particularly true for recycling and related issues, because organizations will have an easier time assessing consumer driven reverse supply chain activities such as recycling and take-back programs.

Industrial ecology could be another beneficiary of GreenSCOR. Industrial ecology is an innovative means of reducing the environmental impacts of an organization's products, or in this case, multiple organizations' products. Of key importance is the ability to identify valuable uses of one organization's waste stream in the production of another organization's products.

Organizations could use GreenSCOR jointly to identify more processes and thus more potential uses for certain waste streams. Essentially it facilitates the growth of industrial ecology practices because more organizations would have better grasp of the relationships between their activities.

Those participating in emission trading programs would have similar benefits. Again, the concurrent benefit is the ability to clearly see how these environmental programs affect the organization's supply chain and ultimately its bottom line.

Another significant benefit of full integration of GreenSCOR is the enhancement of environmental awareness among those with direct authority over pollution and waste generating operations or procedures. Awareness is improved because GreenSCOR utilizes a proven, widely accepted supply chain model with familiar terminology and processes. This will make green concepts more accessible to supply chain managers and increase the likelihood they will be key contributors to successful environmental management overall.

## Improved Supply Chain Management Performance

Supply chain management improvements evolve directly from the improved identification of environmental aspects and impacts. With the GreenSCOR best practices and metrics, logisticians can directly see how improving environmental performance can improve the efficiency of their supply chain operations. Such awareness tends to spark innovation, resulting in dual benefits.

The addition of new processes that address waste generation and disposal are particularly important. Whether the waste is hazardous or not, waste management is a tremendous logistical effort for many operations. Failing to incorporate the costs associated with this process into the full supply chain results not only in higher costs but a loss of potential revenue-generating opportunities.

By tying environmental best practices to existing supply chain metrics, we allow users to see the business impact of environmental issues. This helps bring environmental issues out of the realm of afterthought and into a strategic piece of supply chain management because it can improve the real performance. This leads to more efficient operations and better customer support.

# USING GREENSCOR

Like the overall SCOR model, GreenSCOR was deliberately conceived as a tool to be used by any organization with a supply chain and, specifically for GreenSCOR, any organization that also has environmental impacts associated with its operations. Consequently, the best practices and metrics identified are generic; however, organizations that have already adopted SCOR should have little difficulty incorporating GreenSCOR because their organization-specific adjustments will be in place.

## Data Challenges

One of the key challenges for many organizations will be the collection of the data necessary to begin assessing their progress against the metrics identified. Any organization that has significant environmental impact will almost certainly have a system in place for monitoring and collecting environmental performance data; however, the information is not likely to be organized in a manner that directly matches GreenSCOR metrics. For example, a plant manager may know the plant's air emission levels, but may not be able to assign a value to the emissions from a specific process.

The gap between the supply chain and environmental worlds will become more evident as organizations try to obtain requisite data. Suddenly packaging cost and vehicle trip information will be required for environmental analysis in addition to supply chain analysis. In some instances, there will be items that an organization never measured or tracked.

These limitations, however, represent the learning curve that any new concept must contend with. As green supply chain management gains popularity as a management approach, data tools will need to be modified to collect environmental data as it pertains to supply chain operations.

## Cultural Challenges

As with any new management approach, there is a required cultural shift for any organization that wants to undertake a green supply chain management approach. Supply chain and environmental divisions have long had difficulty understanding each other's goals for the organization, which results in contention.

To overcome this, executives must get the two groups to work together by understanding each other's processes and requirements. Only by changing this culture to one of collaborative management can an organization hope to successfully implement green supply chain management. GreenSCOR can be a great help in overcoming this hurdle. GreenSCOR puts environmental concerns into a language and format the supply chain managers understand and commonly use. This helps bridge the gap that prevents true green supply chain management.

## Training

The SCC currently offers a 2-day course to anyone interested in learning to use the SCOR model. This offers an advantage to the GreenSCOR model, because it is largely based on the SCOR model.

People who want to use GreenSCOR can combine the SCC training with the background material presented in this report to become fully trained on the model. The general analysis approach should be identical to what is used for the SCOR model. Therefore, a great deal of additional training beyond the SCOR model is not needed to implement GreenSCOR.

# PROMOTING GREENSCOR

GreenSCOR is intended for use by both supply chain and environmental managers. Both users can utilize the tool to collaborate with each other and improve performance in their respective area of expertise. The first step, however, is to educate the potential users about the GreenSCOR model.

## Within DoD

Green supply chain concepts can significantly improve end-to-end warfighter support from DoD supply chains. GreenSCOR provides a tool to enable supply chain practitioners and managers in DoD and the services to implement green supply chain concepts that improve performance and reduce costs. Because there is an opportunity to improve operations at reduced cost, it is important to share the GreenSCOR model throughout DoD.

### GREENSCOR EDUCATION

The first step to sharing GreenSCOR internally will be to educate supply chain managers and practitioners on the model. This will start with conference briefings to raise awareness of GreenSCOR. These briefings will highlight the benefits of green supply chain practices for end-to-end supply chain performance and focus attention on the model and how it can be used to enable implementation of cost effective and environmentally sound concepts.

The initial briefings will be followed by more in-depth presentations that cover the development and use of GreenSCOR. These will focus on the benefits of using GreenSCOR to manage both supply chain and environmental processes.

Finally, we will offer assistance to anyone in DoD who uses GreenSCOR. As with any business tool, there will be an associated learning curve, and we will work with process owners to help them use the model in the optimal way. The goal is to achieve GreenSCOR acceptance as a standard tool for improving performance and mitigating environmental impacts.

### Pilot Studies

To educate users further about GreenSCOR, we will perform pilot studies on the use of the model. These studies will focus on DoD supply chains that are being evaluated for process improvements. Many DoD practitioners already use SCOR in evaluating their operations. We will assist them in using GreenSCOR to demonstrate the additional improvements that can be realized.

Pilot studies will prove the performance of GreenSCOR and allow us to point to actual improvements as we continue educating others on the model. Ultimately, the GreenSCOR model will gain acceptance and we will work toward greater use of the model and better end-to-end support of the DoD mission.

## Beyond DoD

Every supply chain has an effect on the environment. Most currently manage that effect as an afterthought—cleaning up after the fact. By managing environmental impacts with the processes that produce them, organizations can reduce the environmental impact and improve supply chain performance. That is why we plan to share the GreenSCOR model with external organizations. This will expose the model to a greater pool of users and give us better feedback on the effectiveness of the model in various environments.

### Inclusion in the SCOR Model

We will present the GreenSCOR model to the SCOR Technical Development Committee for inclusion in the next release of SCOR. Including the changes in an official SCOR release will make the model more palatable to users and allow them to realize the benefits of green supply chain management.

Inclusion in SCOR will also open the model to development and input from users in a variety of industries. As with SCOR, this will make the environmental elements of SCOR more robust and universal.

### Presentations

We will also share GreenSCOR through conference presentations and other mass communication opportunities. By exposing people to the GreenSCOR concept, practitioners can use the model to implement green supply chain concepts and improve their performance.

# Chapter 5
# Conclusion

With GreenSCOR, we have developed a robust green supply chain tool. GreenSCOR is more than an analytical tool; it is a tool for integrating internal organizations. As numerous companies have proven, implementing green supply chain practices can improve supply chain costs and efficiency as well as reduce environmental impacts. GreenSCOR enables these improvements.

Development of GreenSCOR is not the end of this process. In order for GreenSCOR to be effective, we must prove its effectiveness and educate the supply chain community on its use.

To further educate users about GreenSCOR, we will perform pilot studies on the use of the model. These studies will focus on DoD supply chains that are being evaluated for process improvements. The goals of the pilot studies are as follows:

- Demonstrate the utility and effectiveness of GreenSCOR in improving traditional supply chain analysis.
- Demonstrate the utility and effectiveness of GreenSCOR in improving green supply chain analysis.
- The pilot organization selected must enable us to meet the goals stated above. Thus, the pilot organization selected must
- have used SCOR to identify additional opportunities for supply chain optimization by addressing the environmental aspects and impacts illustrated by GreenSCOR; or
- have initiated green supply chain, EMS, or similar comprehensive environmental analyses to identify additional opportunities to reduce impacts by taking full consideration of supply chain activities delineated in GreenSCOR.

Pilot studies will prove the performance of GreenSCOR and allow us to point to actual improvements as we continue educating others on the model. Ultimately, the GreenSCOR model will gain acceptance, and we will work toward greater use of the model and better end-to-end support of the DoD mission.

# Appendix
# Abbreviations

| | |
|---|---|
| EMS | environmental management systems |
| LCA | life cycle analysis |
| SCC | Supply-Chain Council |
| SCM | Supply chain management |
| SCOR | Supply Chain Operations Reference |

Logistics Management Institute
2000 Corporate Ridge
McLean, Virginia 22102-7805
http://www.lmi.org
703/917-9800